Nolan

Insects Affecting Greenhouse Plants

INSECTS AFFECTING GREENHOUSE PLANTS

BY

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THESIS

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Willis James Nolan

ENTITLED Insects Affecting Greenhouse Plants

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF Master of Arts in Entomology

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Recommendation concurred in:*

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*Required for doctor's degree but not for master's.

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I. INTRODUCTION.

The insectary experiments described beyond were carried on in connection with my other work for my master's degree. Owing to the fact that the time available for the work was limited, it thought desirable to study several species at once. In addition, as a basis for work in economic entomology, it was deemed advisable to become personally acquainted with the life histories of the more important insects infesting greenhouses in winter. The results of my observations of the insects used form the basis of this thesis. At this point I wish to acknowledge my indebtedness to the writers mentioned in the list of references for such of their observations as may have been used in this article.

The work was begun under unfavorable conditions. For over a month and a half the thermostat in the greenhouse was not working correctly, and as a result of extreme variations in temperature, plants and insects were often killed, and many of my experiments put to an end. This was especially true in the case of the aphids, when I was using the method of enclosing a leaf on a living plant in a bottle, and closing the opening of the bottle around the stem of the leaf with cotton. In this case, many times I found the temperature had risen so high over night, that excessive transpiration ensued, and the aphids were killed. Later in the year a fungus outbreak swept off all my experiments with aphids. Chrysanthemum plants formed the food of the aphids and the leaf-tyers: while the mealy bugs were kept on Coleus plants.

My best thanks are due to Dr. J. W. Folsom for his interest and assistance in my work. I am indebted also to John J. Davis, of the Bureau of Entomology for confirming my determination of the aphids which I studied.

I had intended to include drawings of each insect in this thesis, and to finish some uncompleted observations on the greenhouse thrips (Heliothrips haemorrhoidalis Bouché), but owing to the fact that I am called away from the university for work in connection with the army the first week in May, I have had to bring my studies to a close.

I. PHLYCTAENIA RUBIGALIS GUENÉE.

The Chrysanthemum Leaf-tyer.

1. GENERAL.

SYNONYMY.

1854 - Phlyctaenia rubigalis Guenée, Deltoides et Pyralites, p. 398.

1863 - Botys oblunalis, Lederer, Viener ent. Monatschrift, p. 372 - 469.

1877 - Botys harveyana Grote, Can. Ent., 9:104.

1878 - Scopula ferrugalis, Buckler, Ent. Mo. Mag., 14:200-204.

Phlyctaenia ferrugalis Huebner. Not available.

1899 - Pionea rubigalis Guenée, Hampson, Proc. Zool. Soc., London, 1899, p. 942.

HISTORICAL.

The insect commonly known as the chrysanthemum leaf-tyer was first described in 1854 by Guenée, who named the species Phlyctaenia rubigalis. In 1863 there appeared a description of the same species by Lederer, who named it Botys oblunalis. This account was followed in 1877 by Grote's description of the adult. The next year Buckler published an excellent account of the larval stages of Scopula ferrugalis, this name being at that time a synonym of Phlyctaenia ferrugalis. In 1890 Riley identified specimens as Botis harveyana. In the next few years the species was described indiscriminately as ferrugalis and rubigalis. Hampson, in his list of 1899, placed rubigalis as a species native to America, and distinct from the European species ferrugalis Hbn., which is now known to be a cosmopolitan species. Phlyctaenia ferrugalis is now placed in the super-

family Pyralidina, family Pyraustidae.

This form undoubtedly arose in tropical regions, because it prefers the heat of the greenhouse to the varying temperatures out-of-doors in northern latitudes. This supposition is borne out by the fact that it has been found in the open in California and Florida, as well as warm regions in other states.

FOOD PLANTS.

Phlyctaenia rubigalis feeds on almost any soft-leaved greenhouse plant, but attacks especially chrysanthemums, Cinerarias, cucumbers, geraniums (Pelargonium), lettuce, parsley, strawberries, sweet peas, and violets. I placed it on Coleus plants, and, although it fed there for a short time, it always crawled off and disappeared within two or three days at the most.

It is reported that out-of-doors, the caterpillar feeds on cabbage, beets, hedge-mustard, ragweed, tobacco, and ornamental plants as well.

INJURY.

As the name leaf-tyer implies, the caterpillar often ties two or more leaves together, not only when it is preparing to form the cocoon, but also in ordinary feeding operations. In case leaves are not close enough to tie together, the larva bends and fastens part of a leaf back upon itself. More than this, when feeding on the leaves, it eats away the whole under surface, and leaves only the upper epidermis. It rarely

attacks the upper surface. The larva likes to work in secluded locations, and hence plants in shady places suffer most. As far as the plant is concerned, the damage consists not so much in its being weakened, as in the fact that the leaves are disfigured, and the market value of the plant is reduced.

2. DESCRIPTION.

EGG.

The egg is very much flattened, — in fact, scale-like in appearance, somewhat variable in outline, but usually broadly ovate. The surface of attachment is more flattened than the outer surface, which is slightly convex. When first laid the egg is translucent, with a characteristic pearly tinge. The average length is 0.8 mm., and the average width is 0.65mm.

The eggs are laid singly or in clusters varying in number from two to more than twelve, and the eggs of a cluster may overlap somewhat. They are usually laid on the underside of the leaf; but I found them also on the sides of flower-pots, and of cages. I often found five or six groups of eggs on a single leaf.

LARVA.

The new-born larva is creamy-white in color, but the body soon turns green when the larva begins to feed. Even after the second moult, the larva is often white in color until it begins to feed again. The general color of the full-grown larva is a translucent greenish white. The head is a dark straw

color with darker mottlings. In the center of each half of the prothoracic shield there is a small conspicuous, black spot. There is also a narrow, dark green, median-dorsal stripe, on each side of which is a much wider, light greenish-white stripe. The surface is very sparsely hairy. The larva has also five pairs of rather long pro-legs, and the last pair project behind when the body is at rest. On the outer surface of the legs are two small black dots. The mature larva, when stretched out, is often nine or ten times as long as wide.

PUPA.

The pupa, usually about one-half inch in length, is dark brown on the dorsal surface and lighter in color on the ventral. A prominent ridge extends along the median dorsal side of the thorax; and on each side of this ridge, each thoracic segment bears two conspicuous hairs, making a total of four hairs to the segment. They are arranged transversely in a line on each segment.

The posterior portion of each abdominal segment is yellow; and thus the abdomen presents an appearance of being banded with yellow and brown alternately. The abdomen bears four pairs of spiracles; and also a pair of hairs on the dorsal surface of each segment. These hairs are more flexible than those on the thorax, and curve backwards and towards the meson. The posterior segment bears a cremaster of eight hooks.

ADULT.

The adult is an inconspicuous, little, pale reddish-

brown moth with a wing expanse of about three-quarters of an inch. The forewings are light clay-brown in color, suffused with a slightly darker reddish, or ochreous brown, and marked with serrate, blackish lines. The hind wings are gray, becoming light brownish towards the apex, and with two discal spots, the costal one prominent. Both wings are bordered with a row of small, well-defined dots. The forewings extend about 17 to 20mm., and the hind-wings 14.5 to 17mm., while the body is only 7.5 to 10mm. long.

No better description of the adult for indentification can be found than that by Grote in 1877, which is here given almost verbatim. The primaries are pale-brown, the extra line fine, blackish, obsoletely denticulate, rather suddenly drawn in at vein 2, thence back again and angulate before the margin. The outer spot is large, and annulate, while the inner spot is obsolete. Before the fringes, which are faintly interlined with pale, and are discolorous, there is a distinct sinus of dark points. The hind-wings are paler than the primaries; are washed outwardly with the same brown as primaries, with a distinct discal dot and median line. Beneath, the color is more ochreous, with the discal dots double on the hind-wings. There is a common exterior line; and on the primaries the veins are partially darker marked, with the terminal points very distinct, and continuous. The head, palpi, and thorax above, are pale-brown; beneath they are concolorous with the under surface of the wings, and glistening.

3. LIFE HISTORY.

EGG and LARVAL STAGES.

The egg period lasts about twelve days, although the time may vary from five days to three weeks. In the experiments conducted by me the average time was seven days.

The eggs are apparently not easily penetrated by water, since there is one report of their hatching after being soaked in water for two days. About a couple of days before hatching the head begins to appear within the egg as a distinct black dot. When first hatched the larva is semi-pellucid, but soon attains a green color when it begins to feed.

Hinds states that the first moult takes place about eight days after hatching, but in my experiments the time varied between five and seven days. The total number of moults was not determined owing to the difficulty in finding the cast skins. The larva very likely devours them. Britton says that there are three moults, but according to Hinds there are four moults in all. The latter observation is also borne out by the work of Fletcher and Gibson. About eight days elapse between the last moult and the time of pupation. The larval stage lasts about twenty-three days, although it may vary from three to five weeks, according to conditions of temperature and food. In two instances I cut down the supply of food, and the larvae pupated at the same time as larvae a couple of weeks older.

The larvae, if undisturbed, usually move about but little. If disturbed, however, they crawl about very rapidly, either forwards or backwards. They naturally prefer to remain

on the underside of the leaf.

When full grown the larva folds back a portion of the leaf in which to pupate; or it ties two or more leaves together to form a pocket in which it spins its cocoon. Here it transforms into a pupa; and the pupal stage lasts from twelve to seventeen days.

ADULT.

The adults are usually most active in the late afternoon. During the remainder of the day they are at rest on the undersides of the leaves of the host plant. If disturbed they fly low, and not very far at a time; and immediately on alighting they try to get on the underside of a leaf. They are readily attracted to artificial lights, and hence are easily captured in light-traps. The female moths die soon after laying the eggs; though one of my specimens which was not fertilised, lived three weeks without any food.

The average time required for development from the egg to the emergence of the adult is from forty-two to forty-four days as determined by my observations. The time for hatching varied from six to seven days; the larval life was consistently twenty-three days; and the pupal stage consumed from forty-two to forty-four days.

On the next page are two tables showing the results in a few typical cases chosen from my experiments. Table I starts with five different individuals, A, B, C, D, E, in the later larval stage: gives the time consumed in the remaining stages of that generation; gives the time consumed in completing

the next generation; and gives the time in the early stages of the succeeding generation.

TABLE 1.

	A	B	C	D	E
Larva encased.	Nov. 1	Dec. 1	Oct. 31	Nov. 3	Nov. 1
Adult emerged.	Nov. 13	Nov. 13	Nov. 13	Nov. 16	Nov. 13
Laid egg.	Nov. 15	Nov. 15	Nov. 15	Nov. 18	Nov. 15
Egg hatched.	Nov. 22	Nov. 22	Nov. 22	Nov. 25	Nov. 22
Larva encased.	Dec. 15	Dec. 15	Dec. 15	Dec. 18	Dec. 15
Adult emerged.	Dec. 28	Dec. 29	Dec. 28	Jan. 1	Dec. 27
Laid egg.	Jan. 1	Jan. 2	------	------	------
Egg hatched.	Jan. 8	Jan. 8	------	------	------

Table 2 is a summary giving the number of days required to complete each stage of the life history as shown by the one complete generation given in each of the five cases in Table 1 beginning with the laying of the egg on November 15, excepting one case, and ending with the emergence of the adult. Strictly speaking, from one to three days should be added to the number of days given in the table to obtain the exact period of the minimum life cycle, because such a period does elapse between emergence and the first egg-laying.

TABLE 2.

	A	B	C	D	E
Egg stage.	7	7	7	7	7
Larval stage.	23	23	23	23	23
Pupal stage.	14	13	13	14	13
Total number of days from egg to adult.	44	43	43	44	43

According to these results, which give the length of a generation as one and one-half months, there may be at least eight generations per year in greenhouses. My results correspond somewhat with those made by Mr. Hinds at Columbus, Ohio. He says, "It is evident that at least five generations are produced in the interval between the middle of September and the middle of the following May, or the time during which most commercial greenhouses are in operation."

4. CONTROL.

NATURAL.

Phlyctaenia rubigalis has an ichneumonid parasite, Apanteles glomeratus Linn. A larva was found by me infested with larvae of this parasite, and it was placed under observation. Two days later the parasitic larvae had transformed to pupae, these being now coal black in color. Some specimens were placed in a bottle, and sixty-five days later the adults emerged. These proved to be Apanteles glomeratus Linn.

ARTIFICIAL.

One remedy, which always works, is hand-picking. There are many other remedies in use, but they have not proved effective in all instances. Spraying has never been a very successful remedy, because the larvae are usually on the undersides of the leaves; but in the case of chrysanthemums it is possible to use a Paris Green spray to better advantage than on any other plants. Spraying with arsenate of lead has been recommended by J. J. Davis as giving desired results. Fumigation with tobacco or hydrocyanic acid gas has not worked out as well in destroying Phlyctaenia ferrugalis as it has in the case of several other greenhouse pests. Mention has been made previously of the use of a light-trap, but the value of this method has not warranted its general adoption.

III. PSEUDOCOCCUS CITRI RISSO.

The Common Mealy-bug.

1. GENERAL.

SYNONYMY.

1813 - Dorthesia citri Risso, Essai, Hist. Nat. des Oranges.

1867 - Coccus citri Bdv., Ent. Hort., p.348.

1875 - Dactylopius citri Sign., Ann. Soc. Ent. Fr., ser.5, 5:319.

1879 - Lecanium phyllococcus Ashmead, Can. Ent., 11:160.

1881 - Dactylopius destructor Comstock, Rpt. U.S. Dept. Agr., 1880, p.348.

1881 - Dactylopius brevispinus Targioni, Annali di Agr., p.160.

1903 - Pseudococcus citri Fernald, Cat. of Coccidae, p.99.

1909 - Pseudococcus citri (Risso), Sanders, Jour. Ec. Ent., 2:438.

FOOD PLANTS.

Pseudococcus citri is found in many parts of the world, and in practically every greenhouse in the country. Consequently the range of food plants is so wide that it would be almost easier to give a list of the plants not affected. The insect seems to prefer plants which will not stand severe treatment, and this affects the type of remedy to be used. The pest works not only in greenhouses, but also out-of-doors in warm climates, such as the citrus regions of California. In the greenhouse, Coleus, geranium (Pelargonium), and sago plum are the plants most affected. Out-of-doors we find the infestation on Rex begonia, Bignonia sp., Bouvardia sp., bottle brush (Callistemon lanceolatus), deer-brush (Ceanothus

integerrimus), orange (Citrus aurantium), lemon (Citrus limonum), pomelo (Citrus decumana), citron (Citrus medica genuiana), Cucurbita, pumpkin, umbrella plant (Cyperus alternifolius), Erythea edulis, Poinsettia, Euphorbia pulcherrima, Filicales, Fuchsia sp., Nerium, Paeonia sp., purple passion flower (Passiflora violacea), Strelitzia regina, S. gigantea, nightshade, Solanum douglasii, variegated wandering Jew (Tradescantia multicolor), tobacco (Nicotiana tabacum), coffee (Coffea arabica), cotton (Gossypium sp.), English ivy (Hedera helix), moon-flower (Ipomoea sp.), Solanium jasminoides, Habrothamnus sp., crane's-bill (Geranium sp.), grape (Vitis vinifera), nettle (Urtica sp.), oleander (Nerium oleander), Plumbago sp., potato vine (Solanium jasminoides), redwood (Sequoia sempervirens), and Tacsonia jasminoides.

INJURY.

The injury is due to the removal of sap from the growing plant, and hence is similar to the effect of drouth. In the case of Coleus the insect works at the base of the stalk of the leaf; and as a result of the drying out, the leaf soon withers, and falls off. One female on a plant will produce a serious infestation in a short time, because she is capable of laying several hundred eggs. When at work on fruit trees out-of-doors, the insect attacks the fruit as well as the tender, growing parts of the plant.

2. DESCRIPTION.

EGG.

The egg is elliptical in shape, and light straw-yellow in color, covered with small particles of white waxy secretion. Its surface is coarsely granulated. Each egg is about 0.25mm. in length, and 0.06mm. in width. A fluffy network of waxy threads secreted by the insect covers the egg-mass, and serves as a protection from predaceous enemies.

LARVA.

The young larva is rather brighter in color than the egg. The female has six-segmented antennae and a large, conical, lower lip reaching almost to the posterior coxae.

ADULT FEMALE.

The color of the full-grown female is white or yellow with a brownish tinge, somewhat darker than Pseudococcus longispinus, and with less powdery secretion covering the body. The legs and antennae are concolorous. There are seventeen lateral appendages, all of which, excepting the posterior four, are short, and not very prominent. Notwithstanding the small size of the filaments, the spinnerets and supporting hairs are rather numerous and prominent, those upon the anal lobes being especially long. The penultimate segment bears on each side a very long seta, and two or three very short ones, together with two conical projections. The surface of the segment is dotted with orifices. The anogenital ring, which is somewhat projected from the penultimate segment, bears six slender setae, each

one-half the length of the setae on the penultimate segment. The antennae are 8-segmented and somewhat pubescent. The distal segment is the longest, being longer than the next two together. Segments 3, 8, 1, and 7 are nearly equal in length, 3 and 2 being longer than 1 and 7 if anything. Next in order come 5 and 6, and last of all, 4. The tarsi are slightly more than half as long as the tibiae, and the claws are large. This species has a brownish, mid-dorsal, longitudinal band which is very characteristic.

MALE ADULT.

Instead of being 7-segmented as in the female, the antennae of the male are 10-segmented. The male is further distinguished by having two long anal filaments about as long as, or longer than, the body. The body itself is rather small in relation to the size of the wings. Although the wing expanse varies between 2 and 3mm., the length of the body is only about 0.75mm. The body is a pale lavender brown, while the wings are a milky-white. The eyes are dark, and surrounded by a light ring of red. Since the male lives only a short time, and food seems unnecessary, no mouth is found, and the head is small.

3. LIFE HISTORY.

EGG.

The time required for hatching varies from one to two weeks according to the temperature. The period of egg-laying is so long, that the eggs first laid hatch before the

female ceases laying. As stated elsewhere the woolly secretion given off by the adult serves as a place for hatching and protection until the young larva goes off to take care of itself.

LARVA.

When the young larvae venture forth from the egg-mass covering, they have assumed a woolly coat, to a slight degree like that of the parent. The young do not grow very rapidly for the first fifteen or twenty days. They are very active, however, and soon after emerging from the egg spread in all directions, and settle, preferably along the midrib on the under sides of the leaves, or in the forks of the young twigs where they may form large colonies, closely packed together. The females continue to move at will throughout their existence, but the males soon spin a small white cocoon in which to pupate.

When the larvae are about one-third grown, about one out of every nine or ten crawls away from the others, and spins an oblong cocoon from a secretion similar to that which is used in forming the egg-covering. But the threads are much finer, and are spun closely together. The cocoon is usually 1 or 2mm., long, and about one-third as wide. Wing pads rapidly appear, and about a week later in cases which I observed, the winged adult emerges.

I attempted to work out the exact number of moults which the female undergoes. My method of doing this was as follows, A small brass ring was attached by paraffin to the surface of a leaf, and a newly emerged larva was then confined within the ring by fastening a cover-glass to the ring with

paraffin, but this plan did not work out for several reasons. In the case of attaching the ring on the under surface, and completely sealing the enclosed space, so as to prevent passage of air from without, transpiration would cause sufficient moisture to collect within to kill the larva. If the glass was not completely sealed, it was found that other larvae would manage to find the opening and crawl in, too. This last objection applied to the upper surface also. Even in cases where these difficulties were overcome, the leaf dropped off before observations were completed. Thus in the limited time available for the investigation, satisfactory results were not obtained. It is the opinion of the writer, however, that successful results may be had by this method if one has plenty of time, and makes enough trials.

ADULT.

Copulation takes place when the female is about two-thirds grown, or about 3 or 4mm., in length. Contrary to the reports of several observers, males could always be found. In one observed case of copulation, I saw four other males in the immediate vicinity. The male, however, dies soon after copulation. The female starts laying about twenty-five days later, and continues to lay for about two weeks. In one of my experiments, the female continued to lay for three weeks. The number of eggs laid may vary from 300 to 600 according to the length of life, and the number of eggs laid daily. I found this number to be variable, most of the individuals in the experiment laying from eighteen to twenty eggs daily, although

in a few instances, this number was doubled.

Shortly before laying eggs the female begins to secrete a waxy substance given forth in the form of long threads which unite to form a network. In this network the eggs are laid, and are given protection from other insects by it. When the female ceases laying, there is usually nothing left of her but a little, dry, wrinkled, lifeless skin. The female continues to feed all the time she is laying. I repeated some of G. C. Davis' experiments by placing adult females in bottles without food. Results were obtained similar to those he described. The females continued to lay for a short time but, of course, they died before they had laid the usual number of eggs. As he says, this experiment and the fact that young and old will remain dormant for several weeks when placed in a cold room, show clearly how tenacious the species is of its continued existence. The eggs first laid are farthest away and beneath, because the female moves ahead as the mass grows. The mass also elevates the position of her body until at the end of egg-laying, she may be more nearly vertical than horizontal.

The following table, chosen from my work, gives the time consumed in the various stages of the life-history of three consecutive generations, and a partial fourth.

TABLE 3.

Generation.	Egg laid.	Egg hatched.	Copulation.	Died.	Period of egg-laying.
1st.	Oct. 9	Oct.11	------	Oct.16	14 days.
2nd.	Dec.13	Dec.24	Jan.19	Dec.28	15 days.
3rd.	Feb.13	Feb.17	------	Mar. 7	20 days.
4th.	Apr.18	------	------	------	

Copulation was actually observed only once during this experiment. From the results above, about six and one-half months were required to complete three generations. This would make nearly six generations a year: although peculiar conditions in the experiments may have given the above result, and the number might be much higher under other conditions. The female began to lay twenty-five days after copulation, and the average time for hatching was eleven days. The period of egg-laying averaged eighteen days, although some authorities place it between seven and ten days.

4. CONTROL.

NATURAL.

The most important natural destroyer of mealy-bugs is the coccinelid, Cryptolaemus montrouzieri Muls. Another coccinelid, Cryptogonus orbiculus Schön., feeds on the eggs and young of Pseudococcus citri, and also Pseudococcus longispinus. Scymnus broculatus, another coccinelid, has also been found feeding on larvae of Pseudococcus citri. Their larvae mimic Pseudococcus citri very closely, even being covered with a

white, waxy secretion.

One of the lace-wings, Sympherobius angustus Banks, is a very excellent parasite of the young larvae. Encyrtus inquisitor Howard, a chalcid parasite, was bred from specimens under Howard's observation.

In addition to the above, there are many other species of insects which prey upon Pseudococcus citri, but since none, even including those given above, form any important means of control in the greenhouse, they will not be mentioned here.

ARTIFICIAL.

Much moisture seems to prove fatal to Pseudococcus citri. In fact, as one of my experiments, some Coleus plants, which were infested in September with Pseudococcus citri were kept well sprayed all the year with water coming directly from a hose, and in no case did the infestation develop sufficiently to prove serious. Although spraying with soap and water, or fir-tree oil, is effective, dipping the plants is even more effective. In the orchards of California, a carbolic acid emulsion spray has yielded very successful results when applied plentifully, and with sufficient pressure. Fumigation gives satisfactory results; and this may be done with either tobacco extracts, or nicotine paper, or, best of all, with hydrocyanic acid gas.

IV. PSEUDOCOCCUS ADONIDUM LINNAEUS.

The Long-tailed Mealy-bug.

1. GENERAL.

SYNONYMY.

1767 - Coccus adonidum Linnaeus, Syst. Nat. Ed. 12, p.140.

1839 - Pseudococcus adonidum Westw., Mod. Class. Ins. 1, Synop., p.118.

1844 - Coccus liliacearum Bouché, Stett. ent. Zeit., p.300.

1844 - Coccus tuliparum Bouché, Stett. ent. Zeit., p.301.

1854 - Coccus zamiae Lucas, Bul. Soc. ent. Fr., ser. 3, 5:107.

1869 - Dactylopius longispinus Targioni, Catalogue, p.[illegible].

1875 - Dactylopius adonidum Signoret, Ann. Soc. ent. Fr., ser.5, 5:306.

1875 - Dactylopius hoyae Signoret, Ann. Soc. ent. Fr., ser. 5, 5:317.

1875 - Dactylopius pteridis Signoret, Ann. Soc. ent. Fr., ser.5, 5:321.

1881 - Dactylopius longispinus Comstock, 1880 Rpt. U.S. Dept.Ag., p.344.

1907 - Pseudococcus longispinus Targ., Carnes, Second Bien. Rpt., Comm. Hort. Cal., p.155.

1909 - Pseudococcus adonidum (Linn.), Sanders, Jour. Econ. Ent., 2:471.

HISTORICAL.

As may be seen from the table above, Pseudococcus adonidum was first described by Linnaeus. Since that time many descriptions have appeared as the insect was found on different plants. It has been recognized at last, however, that these are all one and the same species, and hence there is no need of abandoning the name which Linnaeus first used for the species. As Sanders remarks, "There is no reason why Linnaeus' name of this insect should be discarded in favor of longispinus Targ., when we have such a good description of the insect in Systema

Naturae, Ed. XII, even though the name had been used previously in Fauna Suecica, and omitted from Ed. X."

One of the reasons for such a variety of names was the fact that, each time the species was found on a different species of plant, the finder failed to recognize it as the same species of insect, and so assigned a new name to it.

INJURY and FOOD PLANTS.

The injury consists in extracting so much sap from the plant that the latter does not obtain enough nourishment, and hence dies.

Being found both in greenhouses and outdoors, Pseudococcus adonidum has quite a food-range, but is confined principally to ornamental plants. Among the plants subject to attack are Dracaena, Rex begonia, Calla sp., Cineraria sp., citron (Citrus medica genuiana), Coleus sp., Croton sp., ferns (Filicales), figs (Ficus sp.), Flacourtia sepiaria, Fuchsia sp., Erythea edulis, guava (Psidium sp.), lemon, lobster cactus (Epiphyllum sp.), mango (Mangifera sp.), moon-flower (Ipomoea sp.), Nephrodium sp., oleander (Nerium oleander), Opuntia sp., plum (Prunus domestica), Primula obconica, sago plum (Cycas revoluta), staghorn fern (Platycerium sp.), Stangeria schizodon, Strelitzia gigantea, umbrella plant (Cyperus alternifolius), and Zamia sp.

DESCRIPTION.

LARVA.

The young of this species are born in a pseudovum,

i. e., they are surrounded by a thin pellicle which splits soon after birth. Like Pseudococcus citri, Pseudococcus adonidum gives forth a cottony secretion which serves both as a nesting-place, and as a protection for the young.

Both the male and female larvae are similar to the adult female in shape and color, but are somewhat more flattened. The female larva has only six segments to the antenna, (the sixth being the longest), while the male larva has seven. The tarsi are somewhat longer than the tibiae.

ADULT FEMALE.

The length of the adult female is about 2 1/2 or 3mm., and the width from 1 1/2 to 2mm. In general the insect is white, or tinged with yellow, and has a median dorsal band of brown. The body is well covered with the powdery, white, waxy secretion. Of the eight segments of the antennae, the eighth is the longest; and the others are grouped in length roughly as follows; 2=3; 1=5: 4=6; 7 being the smallest. Furthermore, each segment bears seven hairs, and is brownish. The legs are stouter than in Pseudococcus citri, long, slightly pubescent: the tibiae are twice as long as the tarsi, and the latter have strong claws each provided with a little knob at the end.

On each side of the body are seventeen lateral, waxy filaments, varying in length, but nearly one-fourth as wide as the body. The four posterior filaments are longer than the others; they are even longer than the body itself. On each side of the anal lobes are two minute, sharp spines, around which is

a circle of closely grouped pores.

The apparatus for secreting the waxy threads for the lateral appendages is found in the lateral lobes, in each of which is a space with rounded pores, and in addition two, more or less strong, conical spines. The penultimate segment bears on each side a rounded group of pores, and two short, strong, spines; and also, besides several shorter setae, a seta rather longer than the anal setae. The anal ring is large, bearing six long setae.

ADULT MALE.

The male has a wing expanse of 2.6mm., while the length of the body is 1.3mm., and the width about 0.5 to 1mm. As seen from the dimensions given, the wings are rather long; they are also largely round, and have a more or less purplish, or grayish-red tinge. The prothorax is rather long, rounded on the sides, straight in front, and rounded behind. The abdomen also is long; and its last segment bears two long threads of waxy secretion. In the middle of each lobe are two long hairs, and one smaller hair, around which the waxy secretion is condensed. The head is large, more convex above than below, and pubescent. The antennae bear ten segments. Of these, segment 3 is the longest, then segment 6, and third in length is segment 10, which is a little longer than segment 9, and of just about the same length as 7 and 8. The legs are long, flat, and very hairy. The tarsi are flat, bearing two digitules; the claws are long with rudimentary digitules. The ocelli are

seen on each side just behind the lateral angle of the eye.

3. LIFE HISTORY.

The life history in all stages after birth is so similar to that of Pseudococcus citri that it will not be repeated here.

4. CONTROL

The methods of control are the same as those used against Pseudococcus citri. (See page 20.)

V. MACROSIPHUM SANBORNI GILLETTE.

The Chrysanthemum Black Aphis.

1. GENERAL.

SYNONYMY.

1891 - Siphonara chrysanthemicolens Williams, Sp. Bull. 1, Dept. Ent., Univ. of Neb.

1904 - Nectarophora chrysanthemi (Oestlund), Sanborn, Ks. Univ. Sci. Bull., Vol. 3, No. 1, p. 73.

1908 - Macrosiphum sanborni Gillette, Can. Ent., 40:65.

FOOD PLANTS.

Macrosiphum sanborni is a monophagous species feeding only on chrysanthemum plants.

INJURY.

As this species belongs to the Hemiptera, it is a sucking insect, and consequently drains the plant of sap. Since the insect lives in large colonies, this depletion soon affects the growth of the plant, and will eventually kill it if not checked. Oftentimes, even though the plant is not killed, the foliage is deformed, thus lowering the commercial value of the plant.

2. DESCRIPTION.

EGG.

No eggs were obtained during the course of my work, and I found no published description of them.

ADULT APTEROUS FEMALE.

The abdomen of the wingless female is a dark, reddish-brown, and polished; while the thorax is a little lighter colored, and carinated. The body bears transverse rows of hairs. The legs are stout, having the tip of the femur, base and tip of tibia, and the tarsi, black, — the other portions being a pale brown. The eyes are dark red; and the antennae as long as, or longer than the body. The nectaries are vasiform in shape, black, rather long, with a wide base, and narrow mouth. The anal segments are about the same length as the nectaries, but extending beyond them, very dark, narrowed at the middle, and bearing four hairs which extend backward. The length of the apterous adult is 1.75mm.

ADULT ALATE FEMALE.

In color the alate female is a trifle lighter than the wingless form; and is quite hairy, the hairs being arranged in transverse rows. It has red eyes, and a black rostrum which extends to the second coxae. The antennae are as long as, or longer than the body, more or less glabrous, and black, except the base of the third segment, which is yellow. Segment 3 is the longest, slightly longer than 7, and twice as long as 5, the

latter being slightly shorter than 4. Segments 3 and 4 are tuberculate, and bear many sensoria: while segments 5 and 6 each bear one. The length of the antennae is 2mm., as compared with 1.8mm., the length of the body. The legs correspond to those of the wingless specimens. In the main the nectaries are moderate in size, black, cylindrical, although wider at the base than at the apex, and have a conspicuously rimmed mouth. The tail is ensiform, hairy, upturned, also black, about as long as the nectaries, but extending beyond them. The wings are long and slender, longer than the body by half, clear, and iridescent, and the stigma long and thin. The venation is normal, but the veins are thin.

The descriptions of the female adults are based on those by Fulloway.

ADULT MALE.

No male forms appeared during the course of my experiments, probably because conditions did not tend to check asexual reproduction, and also because time did not permit me to follow enough generations through their life histories.

I could find no published description of the male.

3. LIFE HISTORY.

ADULT.

Both adults and larvae of all stages live together, preferably on the tender, young shoots. The wingless female reproduces viviparously. Different authorities give different

figures as the average number of young produced by each female; and so we find estimates ranging from twelve to one hundred, although in my own experiments they usually ranged from twenty to fifty. In the same way they differ as to the number born per day. Some authorities place it at five, but in my work, although occasionally one female would give birth to ten or eleven young in twenty-four hours, yet the general average was not over two per day. Regardless of the difference in results, the fact remains that plant lice multiply exceedingly rapidly, owing to the fact that they attain maturity in so short a time. Here again the period varies from one week to three weeks. These variations may be explained on the grounds of temperature, moisture, and health of the plant.

I had the opportunity of watching the birth of young in several instances. The time consumed averaged twenty minutes. The abdomen always appeared first, and this part of the young insect's body, as soon as it was exposed sufficiently, moved vigorously up and down, until only the head region remained in the adult. All the while, the legs were folded back on the underside of the abdomen; but now the insect began to move them about, although the body was suspended too high to gain a footing. By twisting the body around, the abdomen was lowered sufficiently to enable the nymph to gain a footing. The adult now crouched down, and the antennae of the nymph were liberated, and began to wave in the air. Then the adult straightened up, and the young insect was free. Stretching its hind legs back, seemingly, to see if the young was free, the

mother waited about a minute, and then moved away. Soon afterwards the nymph began to feed. Its antennae were colorless when first born, but soon afterwards became black.

When the colony becomes overcrowded, or the plant is beginning to dry up, winged forms rapidly appear. The insect is thus enabled to seek out new feeding grounds, and, since the winged form thus developed is also viviparous, a new colony is soon at work.

Following are a few tables showing the development of a few of the individuals observed by me.

TABLE 4.

Generation.	Born.	Reproducing.	Time.	Number.	Date of last born.
1st	Oct. 13	Oct. 26	13 days	43 young	Oct. 28
2nd	Oct. 26	Nov. 7	8 "	42 "	Dec. 5
3rd	Nov. 7	Nov. 24	21 "	32 "	Dec. 20
4th	Nov. 24	Dec. 4	10 "	8 "	Dec. 20
5th	Dec. 4	Dec. 18	14 "	28 "	Jan. 3
6th	Dec. 18	Dec. 29	11 "	46 "	Jan. 10
7th	Dec. 29	Jan. 12	14 "	37 "	Jan. 26
			91 days		

Counting from the first born of every generation, there were seven full generations in ninety-one days, or one generation every thirteen days. At this rate there would be a maximum of twenty-eight generations a year. From the table we notice that one generation took only eight days. At such a rapid rate there might be forty-five and one-half generations a year, but this would probably be a very rare exception.

On the other hand the minimum number of generations for the ninety-one days was three and one-half. This would

give a minimum of about fourteen generations a year. This number may be too high because in some cases the adult did not live as long as if she had been under optimum conditions.

The experiment covered by the table was with the largest line of successive generations I worked with, because my other experiments, and even this one, were cut short by a fungus outbreak.

In the next table is a summary of the young born from day to day as observed from a few of the different individuals recorded.

TABLE 5.

(1)		(2)	
Born Oct. 28		Born Oct. 25	
Dead Nov. 28		Dead Nov. 15	
Nov. 6	2 young	Nov. 4	4 young
7	4	6	3
8	2	7	2
9	2	8	3
10	2	9	2
13	4	10	1
15	3	11	0
24	7	13	3
27	2	14	2
Total	28 young	Total	20 young

(3)

Born Oct. 26
Dead Nov. 16

Nov. 4	2 young
6	7
7	4
8	2
9	2
10	0
13	2
15	2
Total	21 young

(4)

Born Dec. 1
Dead Dec. 31

Dec. 14	2 young
15	2
18	6
19	2
20	2
22	3
23	2
26	6
27	0
28	2
30	0
Total	27 young

(5)

Born Oct. 10
Dead Nov. 26

Oct. 23	2 young
25	4
26	2
27	3
30	11
31	1
Nov. 1	3
2	4
3	1
4	1
6	3
7	4
8	1
9	0
10	2
11	1
13	1
14	0
15	1
22	5
25	1
Total	51 young

(6)

Born Nov. 6
Dead Dec. 28

Nov. 20	4 young
24	7
27	2
28	1
29	0
Dec. 1	1
4	3
5	2
6	1
8	2
9	1
11	2
12	1
13	0
14	0
15	0
18	4
19	1
20	1
22	0
23	1
26	1
27	0
Total	35 young

In only the first of the examples given did the rate per day during the actual egg-laying period rise above two. It is interesting to note that, using the length of life of the

last example as a basis, there is a possibility of a minimum number of only seven generations. Ordinarily, however, the female does not live that long.

My results are not very striking when compared with those given by Gahan, who seems to have had extreme results. I now quote from him.

"The rate of increase is almost incredible, and has led some growers to believe that the pest is a product of spontaneous generation. Some observations taken by the writer will serve to illustrate the remarkably rapid rate of increase in this species. Young agamic (that is, non-sexual) females isolated upon separate plants, began producing young in every case within eight days after birth. Each female produced from four to sixteen young lice per day, and the average number produced by each was about two hundred. ..... It can readily be seen from the figures above that the number of lice upon a plant, which has been neglected for two or three weeks, will be something enormous, even with but one female on the plant to start with."

Gahan doubtless had optimum conditions, because my own experiments, conducted under ordinary greenhouse conditions gave no such startling results. In fact, as I intimated before, Gahan's results are the most extreme of all that I have seen recorded.

4. CONTROL.

NATURAL.

In the presence of too much moisture there is a fungus which spreads very rapidly, Entomophthora aphidis, and destroys Macrosiphum sanborni. Many life histories, on which I was working, were cut short on this account. Out-of-doors the coccinelids feed on plant lice, and doubtless do the same if they happen to be within the greenhouse. There are also hymenopterous parasites, but none of the latter were found during my experiments.

ARTIFICIAL.

Macrosiphum sanborni may be kept under comparatively complete control in the greenhouse either by spraying, or by fumigation. When spraying is resorted to, care must be taken that the spray actually hits the insects, because the latter are killed only by direct contact with the fluid. Either a soap solution, or a spray made of one of the nicotine solutions is recommended. With the latter, directions for diluting are usually furnished by the manufacturers, but judgment must be used in this matter, and the tightness of the greenhouse must also be considered. A soap solution made up of one pound of soap dissolved in about seven gallons of water is recommended by various writers.

VI. APHIS RUFOMACULATA WILSON.

The Green Chrysanthemum Aphis.

1. GENERAL.

SYNONYMY.

? Aphis chrysanthemicola. Not available.

1908 - Aphis rufomaculata Wilson, Ent. News, 19:261-262.

FOOD PLANTS.

Aphis rufomaculata, like its closely allied species, Macrosiphum sanborni, is a monophagous species, and lives only on chrysanthemum plants. I succeeded, however, in inducing it to feed for a day on Coleus plants, as was evidenced by the purplish tinge of the insect twenty-four hours after being placed on the plant. It refused to feed longer than that period on Coleus, however.

INJURY.

As is the case with all Hemiptera, the injury consists partly in the extraction of sap from the living plant, thus checking its growth. In addition to this injury the foliage is often deformed.

2. DESCRIPTION.

ADULT APTEROUS FEMALE.

The general color of the body of the apterous female adult is dark green; while the color of the antennae and legs is somewhat lighter. The larvae are a light green when first

born, but turn darker with each moult. The antennae are seven-segmented. Segment 7 is the longest; segments 3, 6, 5, and 4 are next in length, and just about equal in size to each other; and shortest of all are segments 1 and 2. Segment 7 is about one and one-half times as long as segment 6; while segment 3 is as long as segment 1 and 2 together. On the other hand, segments 1 and 2 are twice as wide as any of the other segments. This insect has a long rostrum; it reaches to the third coxae. The tibiae are terete, and bear several rows of short, stout hairs. The femur is only slightly hairy. The tarsi bear two simple claws which are curved, and come off at right angles. The cornicles are uniformly cylindrical except for a slight constriction just before the apical region, which is as wide as the base. The mouth itself is small. The cauda extends between the cornicles, and is of about the same length as the latter. As is the case in Macrosiphum sanborni, the dorsal surface of the two distal segments bears two pairs of more or less prominent setae. The body is about 1.5mm. in length.

ADULT ALATE FEMALE.

The above description applies also to the winged female; except that in the latter, segment 5 of the antennae is equal to, or longer than segment 7. The thorax is more rounded above than is the case in the wingless female, and varies in color from green to black. The wings are twice the length of the body, the length of the latter being about 1.4mm.

3. LIFE HISTORY.

The life history is not given here because it is similar to that of Macrosiphum sanborni. (See page 29).

4. CONTROL.

The methods of control which apply to Macrosiphum sanborni apply also to Aphis rufomaculata, and hence need not be repeated here. (See page 35.)

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(See Pseudococcus citri Risso.)

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